

Test Report V1.0
Enhanced Low Dose Rate (ELDRS) Total Ionizing
Dose (TID) Testing of the AFL2828SX/CH DC/DC Converter

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Test Date: June 22-July 27, 2007

Test Report: November 2, 2007

I. Introduction

This study was undertaken to determine the total dose hardness of the AFL2828 DC/DC converters. They feature high power density with no derating over the full military temperature range and single output voltage (at 28 volts) and operation with nominal +28V inputs with output power of approximately 112 Watts. This series incorporates International Rectifier's proprietary magnetic pulse feedback technology providing an optimized dynamic line and load regulation response. This feedback system samples the output voltage at the pulse width modulator fixed clock frequency, nominally 550 kHz. Under-voltage lockout, primary and secondary referenced inhibit, soft-start and load fault protection are provided.

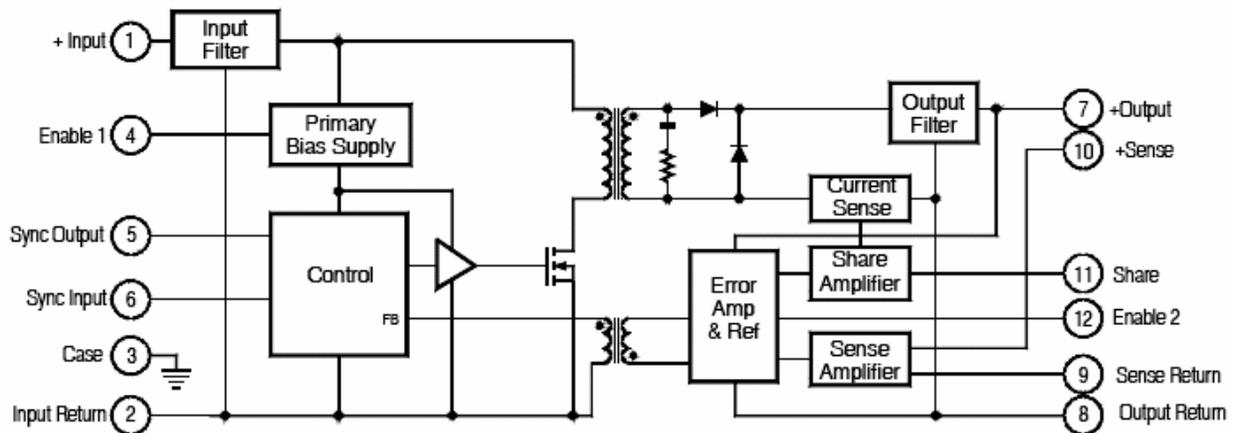


Figure 1: Block Diagram of AFL 2828 DC/DC Converter

II. Devices Tested

The DC/DC Converters were designed and fabricated by International Rectifier. All devices were characterized prior to exposure. The two devices tested (plus one control device) were from the 0533 Lot Date Code (LDC). Delidded device is shown on the next page. Complete package markings for the devices were:

International IOR Rectifier Made in USA 52467
8947 AFL2828SX/ch
DC/DC converter 28V output/112W s/n 0448101 d/c 0533

III. Test Facility and Conditions

Facility: Goddard Space Flight Center Co₆₀ Radiation Effects Facility

Dose Rate: 10 mRad (Si)/s

Dose Measurement Points: 0, 5, 10, 15, 20, and 30 kRad (Si)

Temperature: Room temperature via active cooling

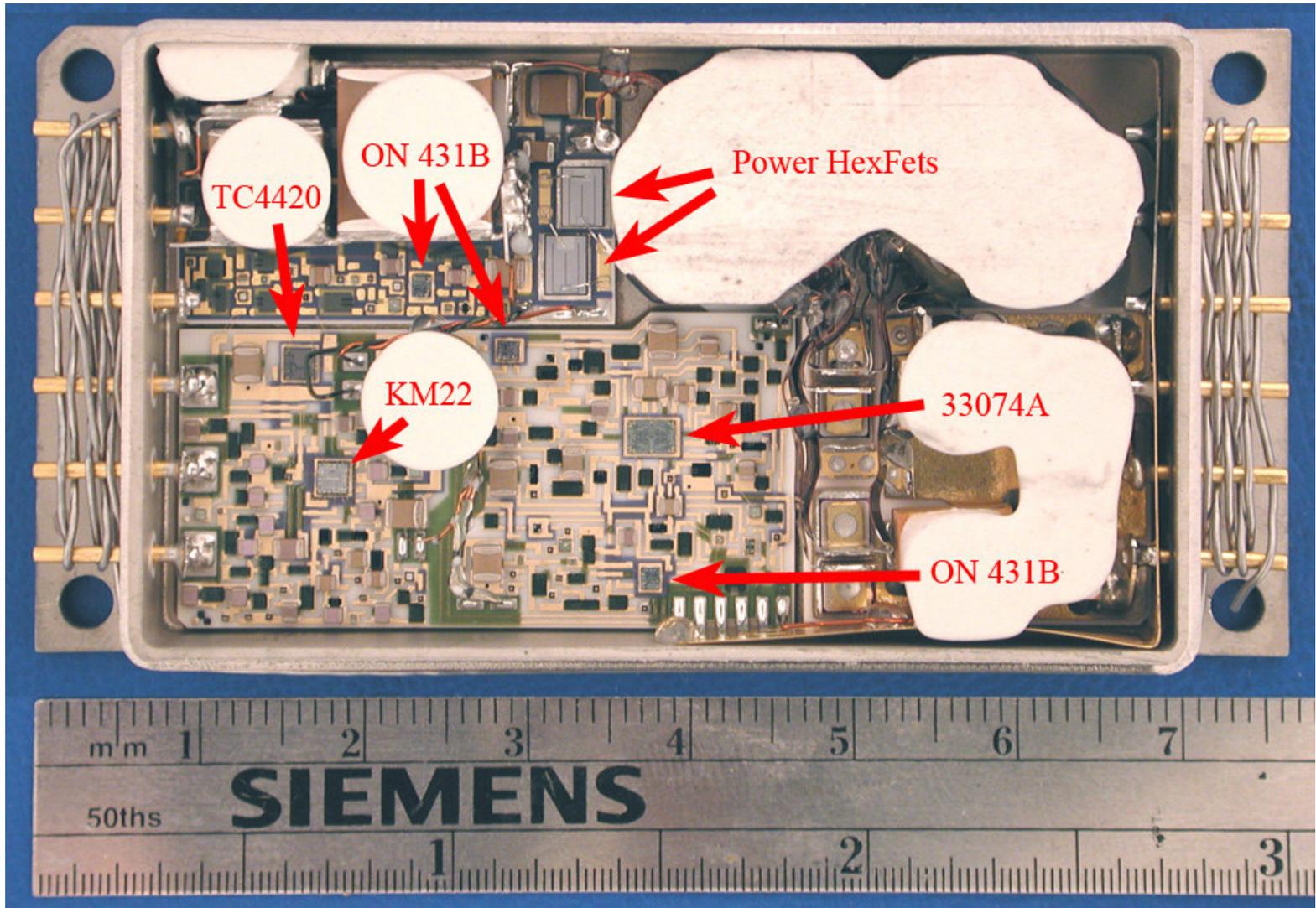
Test Voltage: 28 Volts

Test Loading: (0, 50,100)% (50% = 2 A)

IV. Test Methods

On-site Test Procedures:

1. Verify cooling maintains room temperature on devices. Place bias fixture in specified location for 10 mRad (Si)/s rate. DUT board from Co₆₀ chamber
2. Connect main cable, verify electrical connections and irradiate in approximately 5 kRad (Si) increments.
3. Place Control Part on DUT board
4. Run LabVIEW Test program and repeat up to 30 kRad (Si) level.



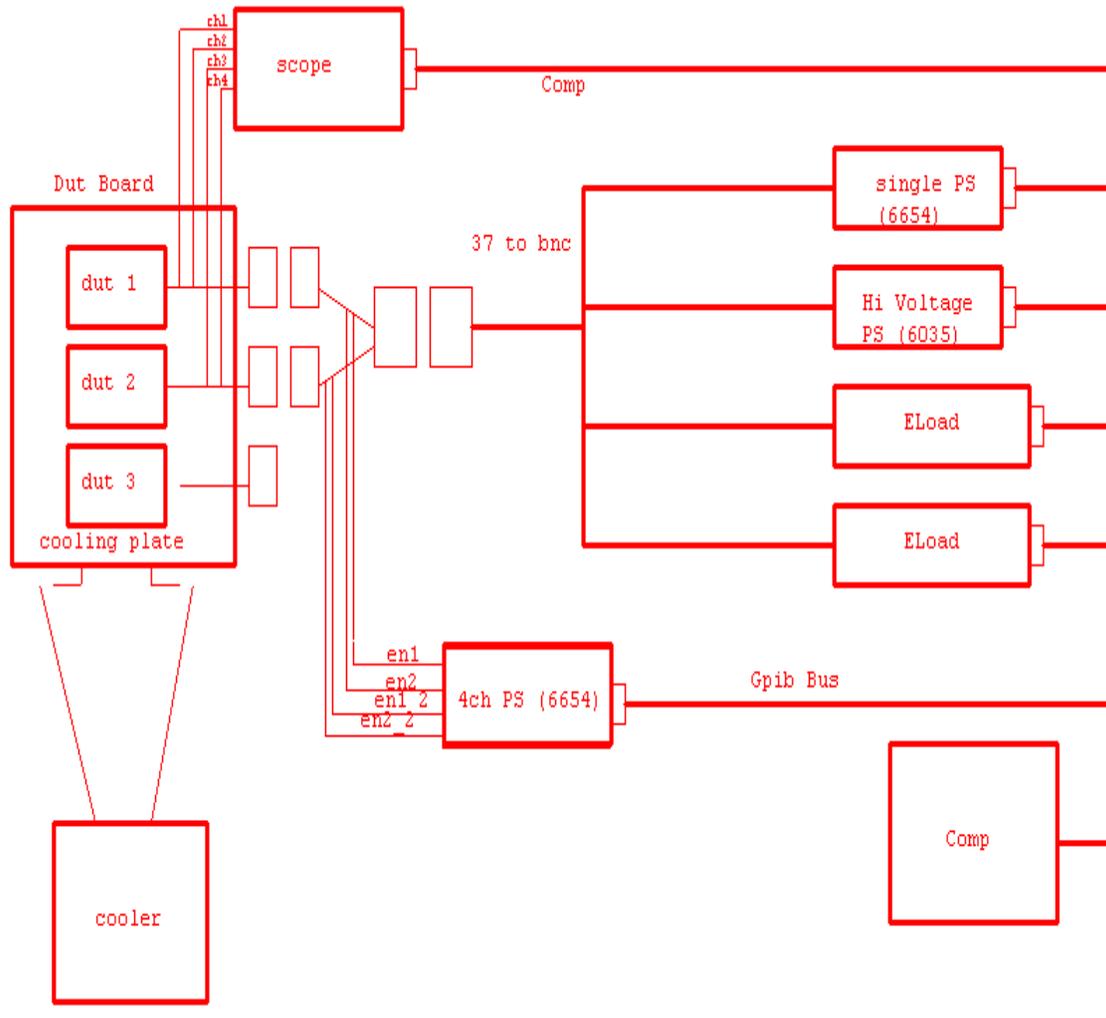


Figure 2 - AFL 2828 Test and Bias Setup Block Diagram

V. Test Requirements

Test	Test Conditions	Min	Max	Units
OUTPUT VOLTAGE REGULATION	No Load, 50% Load, 100% Load	-70	70	mV
OUTPUT RIPPLE VOLTAGE	VIN = 16, 28, 40 Volts, 100% Load, BW = 10MHz		100	mVpp
INPUT CURRENT	VIN = 28 Volts		80	mA
No Load	IOUT = 0		100	mA
Inhibit 1	Pin 4 Shorted to Pin 2		5	mA
Inhibit 2	Pin 12 Shorted to Pin 8		50	mA
INPUT RIPPLE CURRENT	VIN = 28 Volts, 100% Load, BW = 10MHz		60	mApp
EFFICIENCY	VIN = 28 Volts, 100% Load	81		%
ENABLE INPUTS (Inhibit Function)				
Converter Off	Logical Low on Pin 4 or Pin 12		0.8	V
Sink Current			100	μA
Converter On	Logical High on Pin 4 and Pin 12 - Note 9		50	V
Sink Current			100	μA
SWITCHING FREQUENCY		500	600	kHz
SYNCHRONIZATION INPUT		500	700	KHz
Frequency Range		2	10	V
Pulse Amplitude, Hi		-0.5	0.8	V
Pulse Amplitude, Lo			100	ns
Pulse Rise Time		20	80	%
Pulse Duty Cycle				
LOAD TRANSIENT RESPONSE				
Amplitude	Load Step 50%↔ 100%	-1200	1200	mV
Recovery			200	μs
Amplitude	Load Step 10%↔ 50%	-1200	1200	mV
Recovery			400	μs
LINE TRANSIENT RESPONSE				
Amplitude	VIN Step = 1↔ 40 Volts	-500	500	mV
Recovery			500	μs
TURN-ON CHARACTERISTICS	VIN = 16, 28, 40 Volts. Enable 1, 2 on. (Pins 4, 12 high or open)			
Overshoot			250	mV
Delay		0	10	ms

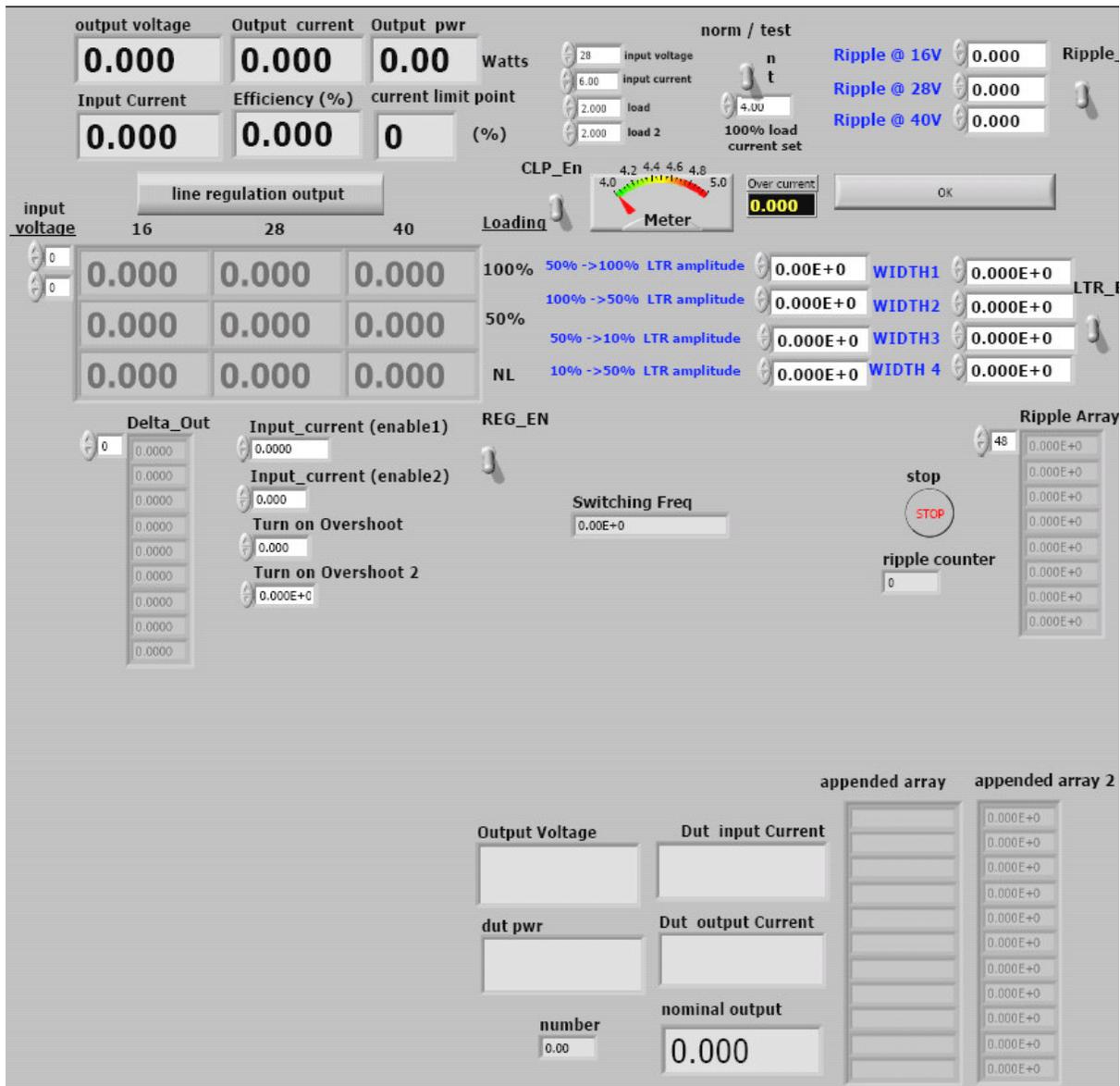


Figure 3 - AFL 2828 LabVIEW Test Program

The following is a list of major equipment used for this test:

Laptop Computer running LabVIEW
HP 6626 4-channel Power Supply
HP 6060B Electronic Load
Tektronix TDS3034b Digital Oscilloscope

Note that all of the specifications indicated on the test requirements were measured except for Enable Inputs and Synchronization Inputs, which were input requirements rather than measurement specifications. A couple of other specifications that were not contained in the logged data were Turn-On Characteristics and Line Transient Response-Amplitude. Those measurements were taken manually and were verified to be within the part specification limits throughout the irradiation.

VI. Test Results

After irradiation of the two test samples to a 30 kRad (Si) level, all parameters remained within the manufacturers specifications. A few measurements of the inhibit current enables were incorrectly taken at the 20 kRad (Si) level, but returned to normal at the next measurement point.

Table 1 shows the results for all the raw data taken during testing. All manufacturer's pre-radiation specifications were met.

Twelve graphs included with this report show the recorded values of the output power and input current as well as the output voltage for three values of V_{in} of (16, 28 and 40) volts, under three load conditions of (0, 50 and 100)%, and over the range of total dose (TID) up to 30 kRad (Si). Dose rate was 10 mRad/s (Si) or less throughout the test cycle. No annealing was required since parameter shifts were negligible.

Devices tracked well over the total dose range. The range of the output voltage under all input and load conditions was well within the manufacturer's spec of 70 mV with the greatest deviation being +44 mV for two readings. Most output voltage readings were in the 5 to 20 mV range of the expected 28 volts.

There were a few operator errors but they are noted with the results. All timing requirements were met with great precision over the entire range of total dose. No radiation data was taken on the DUTs at 0 Rad level. Only Control device readings were taken to verify proper setup and functionality.

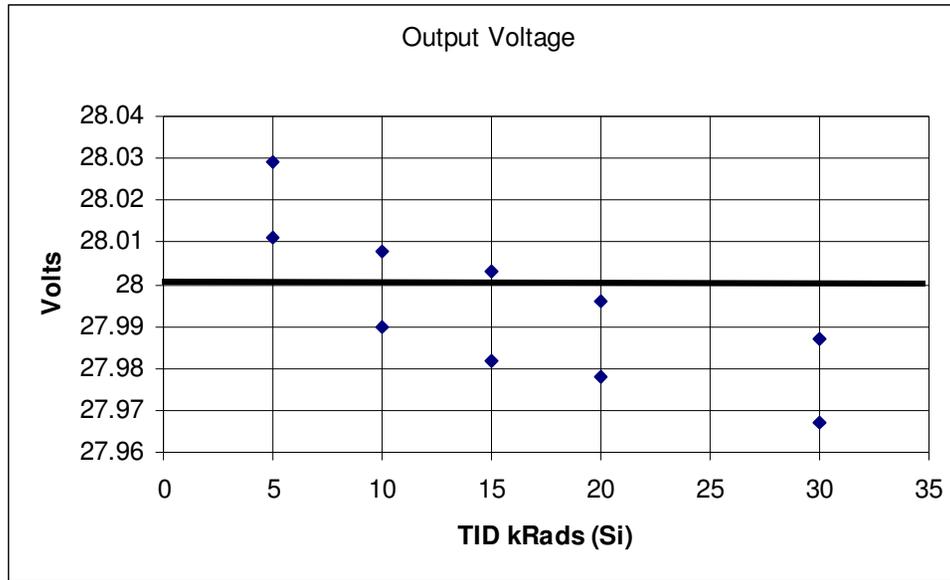
One device was out of spec for input current at 30 kRad (Si). This was well within range of the GLAST project RDM=2 of 4.5 kRad (Si).

Output Voltage	27.975	27.972	27.978	27.974	27.98	28.011	28.029	27.99	28.008	27.982	28.003	27.978	27.996	27.967	27.987
Output Current	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037	4.037
Output Power	112.935	112.924	112.946	112.929	112.957	113.08	113.152	112.996	113.068	112.963	113.046	112.946	113.018	112.904	112.985
Input Current	0.06	0.062	0.062	0.065	0.062	0.06	0.062	0.065	0.067	0.072	0.077	0.075	0.08	0.08	0.085
Efficiency	83.559	83.464	83.394	83.641	83.489	83.441	83.408	83.518	83.433	83.355	83.125	83.532	83.448	84.252	83.596
Current Limit Point	113.85	113.425	113.85	113.85	114.675	112.6	113.425	112.6	113.85	112.6	113.85	112.6	114.25	112.175	116.35
LTR (A) 50% to100%	0.102	0.102	0.1	0.106	0.106	0.113	0.115	0.103	0.1	0.105	0.108	0.106	0.114	0.1	0.006
LTR (w) 50% to100%	60	60	Note 1	60	60	60	60	60	60	60	60	60	60	60	60
LTR (A) 100% to 50%	0.099	0.095	0.09	0.097	0.098	0.103	0.106	0.09	0.097	0.1	0.097	0.108	0.114	0.099	0.117
LTR (W) 100% to 50%	60	80	Note 1	80	60	60	60	80	80	80	60	80	80	60	60
LTR (A) 50% to100%	0.096	0.095	0.094	0.098	0.098	0.086	0.106	0.086	0.096	0.1	0.101	0.101	0.112	0.095	0.118
LTR (W) 50% to100%	80	60	Note 1	80	80	80	80	80	80	80	80	80	80	80	80
LTR (A) 10% to 50%	0.101	0.101	0.096	0.102	0.105	0.108	0.002	0.088	0.1	0.108	0.103	0.112	0.123	0.094	0.121
LTR (W)10% to 50%	60	60	Note 1	60	60	60	60	60	60	60	60	60	60	70	60
Ripple @ 16V	0.01	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Ripple @ 28V	0.015	0.01	0.01	0.01	0.015	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ripple @ 40V	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.01	0.01
Input_current (enable1)	0.006	0.006	0.006	0.047	0.006	0.006	0.006	0.006	0.006	0.006	0.006	(2) 0.054	0.06	0.006	0.006
Input_current (enable2)	0.019	0.019	0.019	0.047	0.019	0.021	0.019	0.024	0.024	(2) 0.032	(2) 0.034	(2) 0.054	0.06	0.037	0.039
switching Freq	569	567	567	568	565	571	574	567	573	569	571	563	564	559	562
input Ripple current	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Output @ 16Vin/100% loading	27.997	28.008	28.019	28.011	28.012	28.041	28.044	28.044	28.042	28.03	28.034	28.03	28.027	28.003	27.951
Output @ 16Vin/50% loading	27.968	27.975	27.982	27.975	27.976	27.994	28.001	27.996	28.009	27.985	28.004	27.982	27.998	27.961	27.972
Output @ 16Vin/0% loading	27.964	27.968	27.976	27.99	27.976	27.986	28	27.989	28.008	27.978	28	27.976	27.994	27.956	27.979
Output @ 28Vin/100% loading	28.001	28.009	28.016	28.013	28.011	28.041	27.999	28.037	28.04	28.026	28.034	28.023	28.026	27.997	28.003
Output @ 28Vin/50% loading	27.98	27.97	27.98	27.975	27.974	28	28.018	27.99	28.008	27.982	28	27.976	27.994	27.958	27.978
Output @ 28Vin/0% loading	27.991	27.971	27.978	27.972	27.971	27.991	28.001	27.986	28.009	27.979	28.001	27.975	27.997	27.956	27.979
Output @ 40Vin/100% loading	27.996	28	28.008	28.004	28.001	28.016	28.018	28.026	28.032	28.015	28.025	28.012	28.018	27.986	27.994
Output @ 40Vin/50% loading	27.974	27.974	27.979	27.974	28.972	28.001	28	27.99	28.005	27.98	27.998	27.978	27.991	27.954	27.971
Output @ 40Vin/0% loading	27.964	27.968	27.974	27.971	27.967	27.984	28.001	27.985	28.007	27.976	28	27.972	27.994	27.953	27.976
Line Transient Response	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40
Measured Parameters/DUT	C-5k	C-10k	C-15k	C-20k	C-30k	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
	CONTROL	CONTROL	CONTROL	CONTROL	CONTROL	5 krad DATA		10 krad DATA		15 krad DATA		20 krad DATA		30 krad DATA	

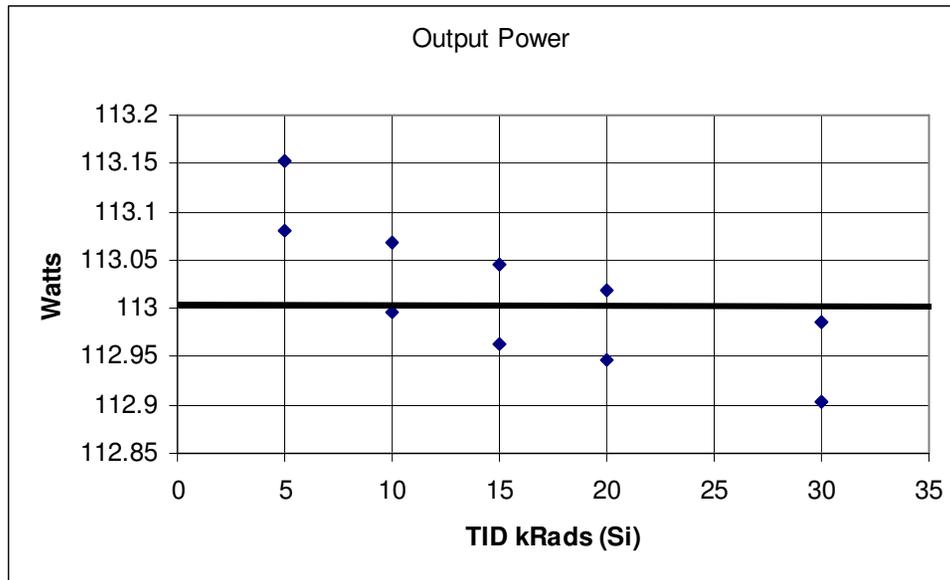
NOTES:

- 1) Reading had to be entered manually. Ranged from 60-80 us. These readings missed.
- 2) Errors made in manual measurements of inhibit current enables at 20k . Data returned to normal on the next level

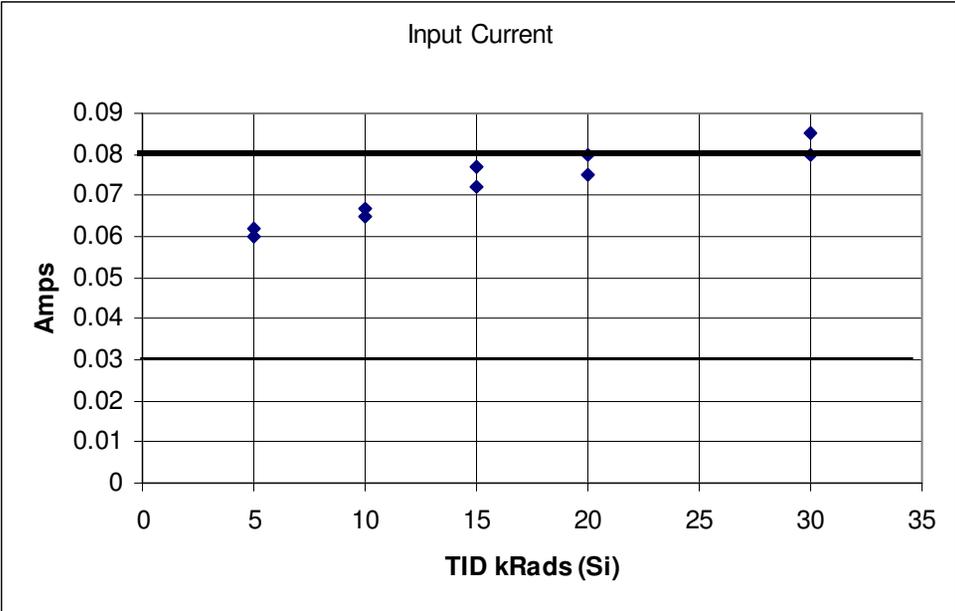
Table 1 – TID Test Results for AFL 2828



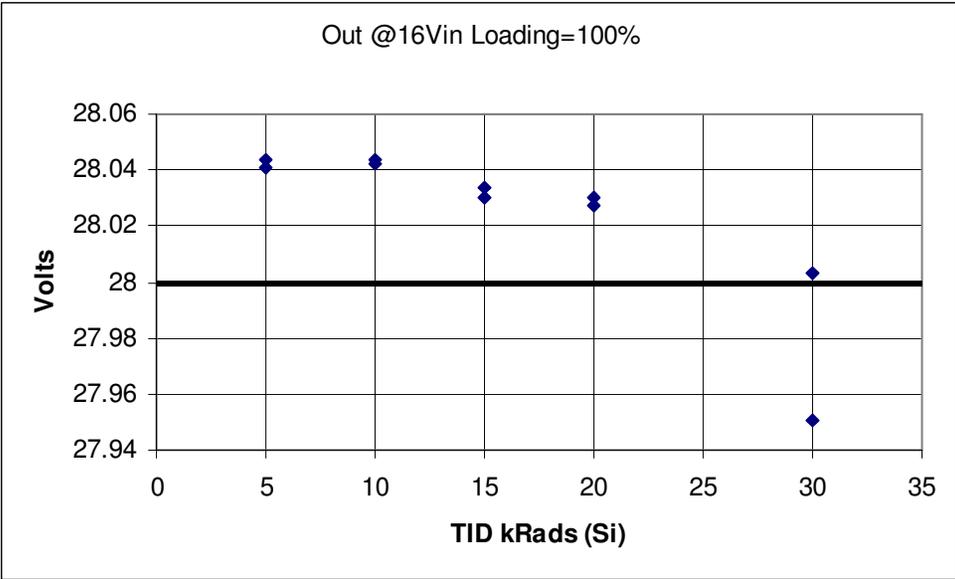
Tolerance for output of 28V **not specified** under all input and load conditions.
Dark lines indicate manufacturer's spec. for each graphed parameter.



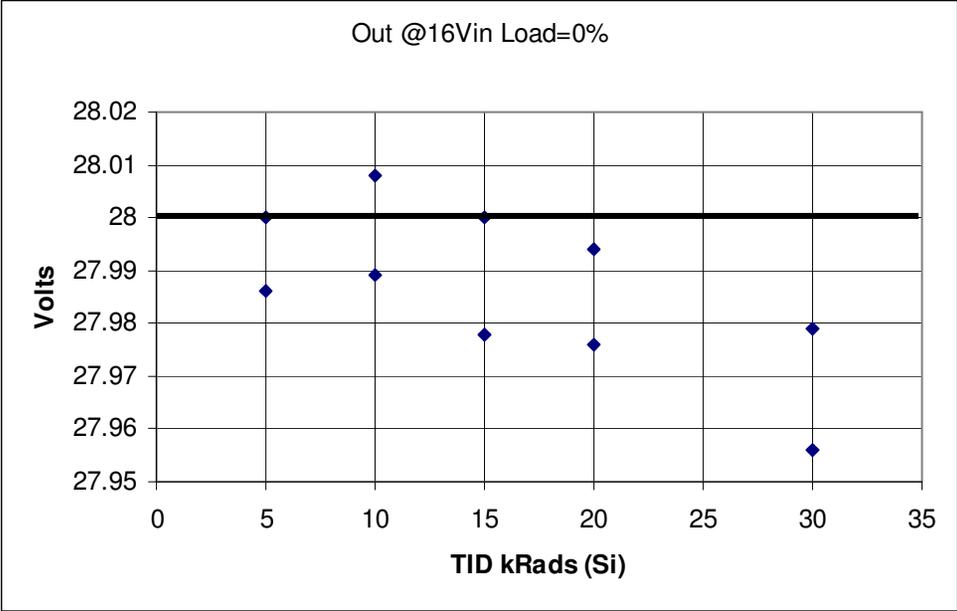
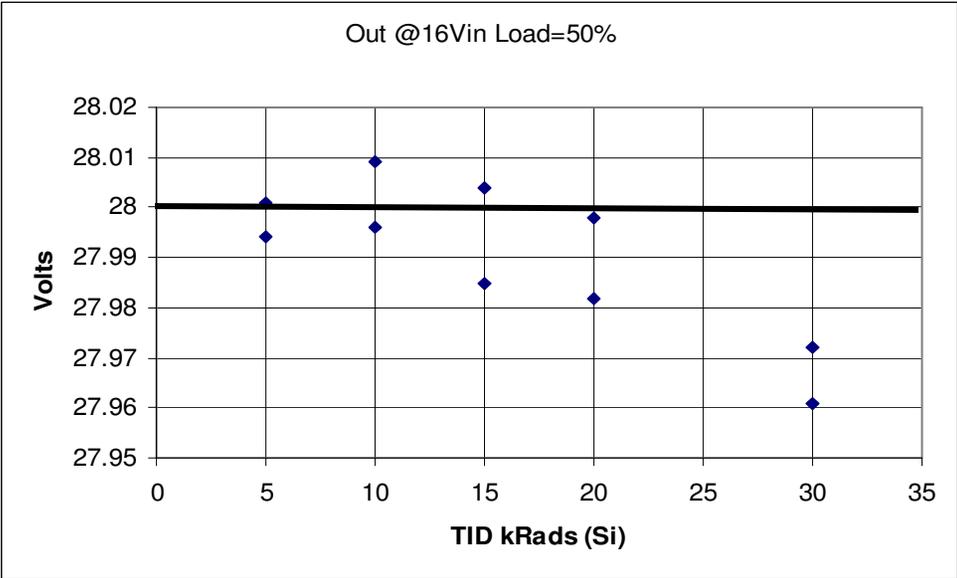
Spec limit given as 113 W maximum without reference to input voltage, load or tolerance.

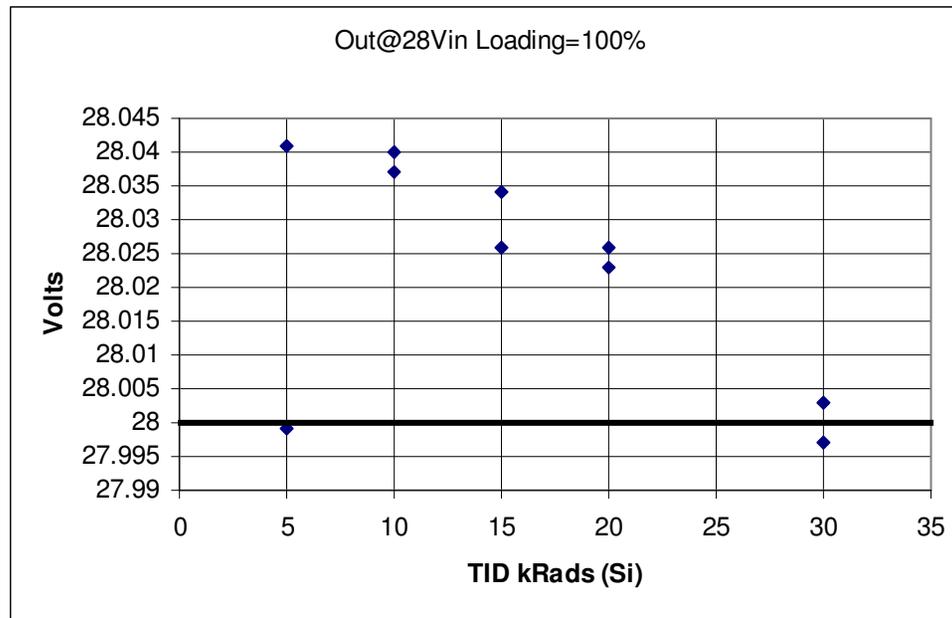


Maximum input current **only specified** at 80 mA for a V_{in} of 28V with no load.



Output specified for **single** condition of $V_{in}=28V$ at 100% load.
Min 27.44V
Max 28.56V
Both limits are off the graph.





This is the only Vout spec that was called out by the manufacturer's data sheet.
 Min 27.44V
 Max 28.56V
 Both limits are off graph.
 All readings were well within spec.

